Order Code IB86121

CRS Issue Brief

Space Launch Options

Updated April 6, 1990

by
Marcia S. Smith
Science Policy Research Division

CONTENTS

Space Launch Options

SUMMARY

Since the 1986 space shuttle *Challenger* accident, the United States has been reassessing its launch vehicle capabilities and needs. Both NASA and DOD now support a "mixed fleet," using both the shuttle and Expendable Launch Vehicles (ELVs). DOD has increased its order for a variety of ELVs as part of its "Space Recovery Plan." NASA is procuring commercial ELV services rather than the rockets themselves, which will be launched by a commercial company rather than the Government. Both DOD and NASA are involved in studies of future launch vehicles.

Several U.S. companies are marketing launch services both to NASA and to commercial satellite owners (primarily those who own communications satellites). Congress and the White House have taken steps to facilitate commercial launch vehicle services companies since 1983. Other countries have their own launch capabilities, and some U.S. companies are turning to them for launch services. The main competitors are Europe's Arianespace, which operates the European vehicle Ariane, as well as China and the Soviet Union.

Among the issues facing the 101st Congress are: the use of foreign launch vehicles for U.S.-built satellites, facilitating the U.S. commercial ELV industry, and choices for the development of future launch technology.

ISSUE DEFINITION

In the wake of the space shuttle *Challenger* accident and the failure of other launch vehicles in 1986, U.S. national policy changed significantly regarding the use of the space shuttle and expendable launch vehicles (ELVs). Today, Congress is involved in decisions concerning what U.S. launch vehicles will be available in the future, whether the Government or the private sector will launch them, and whether American-made satellites can be launched on ELVs built by the Soviet Union and China.

BACKGROUND AND ANALYSIS

U.S. Launch Vehicle Policy

The National Aeronautics and Space Administration (NASA) was created in 1958 to conduct U.S. civilian space activities. Military space activities are conducted by the Department of Defense (DOD). During the early part of the space program, both agencies developed launch vehicles to satisfy their requirements. DOD developed the Atlas, Delta, and Titan families of launch vehicles from ballistic missile technology; NASA developed Scout and Saturn (the Saturns, used to send Apollo crews to the Moon, are no longer produced). All these launch vehicles can only be used once, and hence are called Expendable Launch Vehicles (ELVs). Each version has a different capability to put satellites in orbit. From the least to the most capable, they are: Scout, Delta, Atlas, and Titan. NASA and DOD use whatever vehicle they need based on the size, weight, and destination of the spacecraft, not on which agency sponsored the launch vehicle's development.

In 1972, President Nixon approved NASA's plan to create a reusable launch vehicle, called the space shuttle, and directed that it become the Nation's primary launch vehicle, replacing all the ELVs except Scout. This would make NASA and DOD dependent on a single launch vehicle for access to space, but, in theory, the resulting high launch rate for the shuttle would significantly reduce the cost per flight. The shuttle was first launched in 1981, and was declared operational in 1982. The phase-out of the ELVs began, but, in 1984, concerned about having "assured access to space" if problems developed with the shuttle, the Air Force successfully argued that it needed a "complementary" ELV as a backup to the shuttle and initiated what is now known as the Titan IV program. Production lines for the Delta and Atlas were closed down, and it was expected that only the shuttle and Titan IVs would be in use by the end of the 1980s.

After 24 successful missions, the space shuttle program suffered tragedy on Jan. 28, 1986, when the space shuttle *Challenger* exploded after launch. In addition to the human loss, the *Challenger* accident deeply affected U.S. space launch policy, and demonstrated the vulnerability of relying too heavily on a single system. Many military and civilian satellites had been designed specifically to be launched on the shuttle, and could not have been transferred to ELVs even if they were not already being phased out. The few remaining ELVs had their own problems in 1986. A

Titan exploded in April and a Delta failed in May, which also grounded Atlas because of design similarities.

As a result of the 1986 failures, U.S. policy has been significantly revised from primary dependence on the space shuttle to a "mixed fleet" approach. The country once again will have a wide variety of launch vehicles to choose from. After the current backlog of missions is dealt with, the shuttle will be used principally for missions that require crew interaction, while ELVs will be used for other spacecraft. President Reagan also decided that commercial payloads could be flown on the shuttle only if they are "shuttle-unique" (capable of being launched only by the shuttle) or if there are special foreign policy considerations. NASA contracts with most commercial customers (primarily owners of communications satellites) for launches on the shuttle were terminated, and they have had to turn to U.S. or foreign launch service companies. (One company, Contel, has filed suit against NASA for breach of contract.)

Beginning in 1983, the White House and Congress have taken steps to facilitate the nascent U.S. commercial launch services companies. NASA's marketing of the space shuttle to commercial users had been viewed as a major obstacle to their success (the companies argued that the government was subsidizing shuttle launch prices). Removing the shuttle as a competitor to other launch services, and other governmental actions (such as making it easier to secure adequate insurance, and requiring NASA to purchase launch vehicle *services*, rather than launch vehicles), have helped U.S. launch services companies, although the Europeans already are strong competitors, and the Soviets and Chinese are viewed as potential threats.

With the adoption of the mixed fleet policy, DOD has increased its order for Titan IVs, is refurbishing Titan II missiles for use as space launch vehicles, and is procuring two new Medium Launch Vehicles (MLVs), one based on Delta and the other on Atlas. DOD calls its procurement effort the Space Launch Recovery Program. NASA is purchasing ELV services directly from commercial launch service providers. Congress continues to show interest in steps it could take to further assist the commercial launch services companies. Legislation introduced in 1989 (H.R. 2674) would require (among other things) that DOD as well as NASA purchase launch services instead of the launch vehicles themselves (with certain exceptions). Language was also proposed in the FY1990 NASA authorization bill (H.R. 3729, see **Legislation** section) that would force NASA to justify use of the space shuttle for launching satellites that do not require the presence of humans. While the number of satellites planned for launch via the shuttle has been sharply reduced since *Challenger*, there are still a few.

Launch Vehicle Options

Space Shuttle

The space shuttle returned to flight status on Sept. 29, 1988, with the launch of *Discovery*. With a fleet of four orbiters, NASA plans to build up to a flight rate of 8-14 flights per year, as opposed to the 24-per-year rate planned prior to the *Challenger* accident. The amount of payload that can be launched on the shuttle was

reduced from 29,250 kg to 24,750 kg following *Challenger*, and plans to launch the shuttle from California's Vandenberg Air Force Base have been indefinitely postponed. NASA is planning to develop an Advanced Solid Rocket Motor (ASRM) which will improve the shuttle's performance by 5,400 kg. It has named a contractor team -- Lockheed and Aerojet -- to design, develop, and produce the ASRM. ASRMs are scheduled to be phased into use beginning in 1994, but the program is controversial (see **Issues** section).

Launch manifests for both the shuttle and ELVs are dynamic, changing to reflect schedule delays and other circumstances. The most recent shuttle manifest was issued by NASA in January 1990, showing 74 shuttle flights planned from January 1990 through September 1996, of which four are dedicated DOD missions.

U.S. Expendable Launch Vehicles (ELVs)

Titan II and IV. As noted, 2 years before the *Challenger* tragedy, the Air Force won congressional approval for a new ELV, called the Titan IV, to provide "assured access" to space. The original plan was to procure 10 Titan IVs, with a launch rate of two per year between 1988 and 1992. Congress has subsequently authorized the Air Force to purchase 23 Titan IVs, and the Air Force has requested 26 more. Originally, the Titan IV was to be used only for geosynchronous launches from Cape Canaveral, FL, but now some polar orbit launches from Vandenberg Air Force Base, CA, are also planned. The Titan IV will have a payload capability to geosynchronous orbit of about 2,200-4,500 kg, depending on the type of upper stage used. The Titan IV will be used to launch early warning, reconnaissance, and other national security payloads, and possibly for space science missions. The first Titan IV was launched successfully on June 14, 1989, from Cape Canaveral; the payload was a new missile warning satellite. The Air Force plans to launch nine Titan IVs per year by 1995 and NASA may buy one to two Titan IVs each year. Titan IVs cost approximately $90 million each.

The Air Force is also refurbishing Titan II intercontinental ballistic missiles, which are no longer needed, for use as space launch vehicles (Titan IIs had been used in the 1960s as launch vehicles). The first launch of a refurbished Titan II took place in September 1988. It can carry up to 2,340 kg to low Earth orbit.

Medium Launch Vehicles. The Air Force developed two new Medium Launch Vehicles (MLVs) to augment its launch options. The Air Force awarded the MLV I contract to McDonnell Douglas to build seven Delta II vehicles, with options for 13 more. The Air Force plans six to eight flights between 1989 and 1991, and four flights per year thereafter. In the 1990s, NASA will use three to five Delta IIs per year. Each Delta II costs approximately $20 million. The Delta can launch 5,000 kg to low Earth orbit or up to 1,800 kg to Geostationary Transfer Orbit (GTO). The first Delta II launch took place on Feb. 14, 1989, lifting a navigation satellite (Navstar 2-1) into orbit. The contract for a second MLV (MLV II) was awarded to General Dynamics for an Atlas Centaur derivative. Each vehicle will cost approximately $40 million, and will be able to launch 7,250 kg to low Earth orbit, or 2,600 kg to GTO. A unique aspect of the MLV program is that one of the Air Force's criteria was that each MLV be adaptable for commercial use.

Private U.S. ELV Launch Services. In May 1983, President Reagan issued a policy regarding the commercialization of ELVs, stating that the Government would facilitate the transfer of ELV operations to the private sector. In February 1984, he issued an Executive order designating the Department of Transportation (DOT) as the lead agency for this activity. Congress also supported the commercialization of ELVs under DOT in the Commercial Space Launch Act of 1984 (P.L. 98-575). As noted earlier, in August 1986 the President announced a policy to limit the use of the shuttle for commercial and foreign launches, which further facilitated the emergence of a commercial launch vehicle industry. Since then, Congress and the Administration have worked with the commercial ELV firms in resolving issues such as insurance liability (P.L. 100-657, the Commercial Space Launch Act Amendments) and use of Air Force launch facilities.

The three major U.S. launch vehicle manufacturers all offer their vehicles on a commercial basis. According to a manifest released by DOT in November 1989, McDonnell Douglas will launch nine Delta vehicles on a commercial basis between 1989 and 1995; General Dynamics will have 12 commercial Atlas launches; and Martin Marietta will launch the Titan five times on a commercial basis. Several companies offer sounding rocket launch services (which do not achieve orbit, but fly a suborbital trajectory and are often used for microgravity materials processing experiments.) Eight commercial sounding rocket launches are planned. The first orbital commercial launch (by McDonnell Douglas) was accomplished in 1989. A commercial Titan launch failed in March 1990 and may complicate Martin Marietta's marketing plans.

Government Use of Private Launch Services. While DOD is buying launch vehicles which it will launch itself, NASA and the Department of Commerce (through NASA) are buying launch services from the private sector, a change in that NASA used to buy and launch the vehicles; now the launches will be conducted by private firms. NASA anticipates that by 1991 it will acquire five to nine launches per year on a competitive basis from the private launch industry. According to NASA, this will help the launch industry "sustain operations and compete effectively." In June 1989, NASA secured its first commercial launch contract to carry its Mars Observer spacecraft into orbit on a Titan III booster in 1992.

Pegasus. Orbital Sciences Corp. (OSC) and Hercules Aerospace Co. jointly developed a vehicle called Pegasus. It is launched from an aircraft (a B-52) and can place 300-400 kg into low Earth orbit. The first launch was successfully achieved on Apr. 5, 1990. The cost is estimated at $6-7 million per launch. Potential users of Pegasus include DOD, which is studying concepts for placing small satellites, called Lightsats, into orbit on short notice (e.g., in times of crisis), using small launch vehicles as a supplement to some of the large expensive satellites currently built for national security purposes. NASA is another potential user, for small scientific spacecraft. The first launch carried two small test satellites, one for DOD and one for NASA. Arianespace of France has signed a preliminary agreement with OSC and Hercules to market Pegasus in Europe exclusively.

Future U.S. Launch Vehicles

Advanced Launch System (ALS). In 1987, the Air Force initiated a program called the Advanced Launch System (ALS) for launching heavy payloads into orbit at significantly lower cost than existing ELVs. A driving force behind the program was early deployment of elements of the Strategic Defense Initiative (SDI). This link between ALS and SDI caused difficulties for the program because Congress did not want to approve early deployment of SDI, and put a number of restrictions on the ALS program to prevent its use for that purpose. Originally conceived as an evolutionary family of increasingly capable launch vehicles to be available beginning in the early 1990s, ALS transitioned into a technology development program with no specific launch vehicle in mind. DOD has overall program responsibility, including systems engineering and integration, while NASA is in charge of liquid engine technology development.

The goal of the ALS program generally is to design launch vehicles that can significantly reduce the cost of launching spacecraft. The original goal was to reduce costs by a factor of 10, although the Air Force indicated in 1989 that the goal had been revised to only 3-5 times less than current costs. The capability of the launch vehicle (how many kilograms it can launch) could be anywhere from a medium lift (Titan-class) to a heavy lift (Saturn-class) vehicle, depending on requirements.

Through FY1990, funding for ALS was provided to the Air Force (which passed some of it on to NASA) and the SDI Office (SDIO). SDIO and the Air Force have decreased their support for the program recently, however, as reflected in the FY1991 budget request: SDIO is requesting only $25 million for ALS (down from approximately $100 million in FY1990) and the Air Force is requesting $60 million ($100 million was appropriated for FY1990, but the Air Force plans to spend only $86 million on ALS this year). The Air Force issued a stop-work order on the development of ALS vehicles in December 1989; the effort now will focus on engines, work that is primarily done by NASA. For the first time, NASA is requesting ALS funding directly in FY1991 ($43.9 million).

Shuttle-C. For many years, NASA has expressed interest in developing an automated version of the space shuttle that would be optimized for carrying cargo into space without a crew. The shuttle's orbiter would be replaced by a cargo pod that could take 50,000 to 68,000 kg into low Earth orbit. Thus, the new Shuttle-C would be in between the capabilities of the existing shuttle and the ALS. NASA feels that Shuttle-C has several advantages over ALS, especially the fact that it would use proven technology, and could be available sooner than ALS. NASA sees Shuttle-C as a near-term limited flight rate vehicle. One potential use of a Shuttle-C would be to launch components of the U.S./International space station instead of launching them on the existing shuttle. This would result in fewer launches being needed to place the station in orbit. Shuttle-C studies are now underway, but NASA has not requested funding for developing such a vehicle.

Future Piloted Space Transportation Systems. The existing space shuttle system is expected to reach the end of its operational lifetime around the turn of the century. NASA has initiated preliminary studies of vehicles that could replace the shuttle as a personnel transport vehicle in the post-2000 timeframe, focussing on three alternatives: evolutionary development of the existing space shuttle system;

development of a new Personnel Launch System (PLS); and development of an Advanced Manned Launch System (AMLS). Studies will focus on improving cost effectiveness, increasing reliability, and enhancing performance margins.

National Aero-Space Plane (NASP). NASA and DOD are jointly conducting research on a transatmospheric vehicle, called the National Aero-Space Plane (NASP) program. The research program will develop technologies for a vehicle that is totally reusable and can take off and land on runways. However, the lift capability of the vehicle will probably be limited and its mission has not been specifically defined. NASP has become very controversial in the 101st Congress, and is discussed in more detail in CRS Issue Brief 89128, *National Aero-Space Plane.* In brief, DOD was the lead agency for NASP, and was expected to fund 80% of the program, with NASA providing the other 20%. In its April 1989 budget submission for FY1990, however, DOD withdrew its support of the program and recommended transfer of the program to NASA along with $100 million in FY1990, but no funding in future years. After a review by the National Space Council, President Bush took a more moderate stance and recommended that the program continue to be a joint DOD/NASA project, and that each agency contribute $127 million in FY1990, with future year funding from both agencies. Sharp disagreement subsequently developed between the House and Senate over this program, though ultimately Congress appropriated $254 million, but not split evenly: DOD will provide $194 million and NASA $60 million. For FY1991, DOD is requesting $158 million and NASA is requesting $119 million.

Foreign Launch Capability

The French company Arianespace, the People's Republic of China, and the Soviet Union all have indigenous launch capabilities and are marketing launch services today. All vehicles being offered are ELVs.

Arianespace. The European Space Agency (ESA) developed the Ariane series of vehicles, which is now operated by the French company Arianespace. Arianespace is owned by the French space agency (CNES), 36 European aerospace companies, and 13 banks. Ariane was first test-launched in 1979, and began operational launches in 1982. Despite several failures, Arianespace has been very successful in marketing its services, and is the main competitor to U.S. companies.

The European Space Agency continues to develop new versions of Ariane and, as each vehicle becomes operational, responsibility for marketing and launch is transferred to Arianespace. Ariane 4 is the most recent addition to the Ariane family, and can launch 1,900-4,200 kg to geostationary transfer orbit (GTO). It is the only version of Ariane now in use. A launch failure in February 1990 has grounded the Ariane program temporarily; it is not clear when flights will resume. ESA is currently developing the Ariane 5 with even greater lift capability (5,000-8,000 kg to GTO).

China. The People's Republic of China is marketing its Long March family of launch vehicles. The Long March 3 (CZ-3) vehicle reportedly can carry 1,360 kg to GTO (slightly more than the U.S. Delta vehicle), and China plans to upgrade the vehicle.

In the fall of 1988, the U.S. Government agreed to grant three export licenses for satellites manufactured by Hughes Aircraft to be launched on Chinese vehicles. Two are communications satellites being built for Australia (Aussat) and one is the refurbished *Westar 6* satellite, placed into orbit in 1984 by the space shuttle, and later retrieved by shuttle astronauts (after its engine did not fire properly and it could not be placed into a higher orbit). *Westar 6*, now named *Asiasat 1*, is owned by the Hong Kong-based Asiasat Co. (of which China's International Trust and Investment Corp. is a one-third owner). The Reagan Administration granted the export licenses on the conditions that China: (1) sign three international treaties related to liability for satellite launches and other subjects; (2) negotiate with the United States a fair trade pricing policy for its launch services so that it does not unfairly compete with U.S. companies; and (3) establish a government-to-government level regime for protecting technology from possible misuse or diversion. The granting of export licenses could have been disapproved by Congress within 30 days. Hearings were held on this issue, but Congress did not disapprove the licenses. China met the conditions and approval was granted by the United States and COCOM, clearing the way for export of the satellites.

On June 5, however, due to the continuing instability in China, President Bush suspended all military exports to China indefinitely. The ban included the three satellites, since they are on the Munitions Control List. Language that would have placed restrictions on exporting the satellites to China was included in several pieces of legislation, but only one was enacted, the FY1990 Commerce, Justice, State and Judiciary appropriations (P.L. 101-162). According to that Act, no money in the appropriations bill can be spent to reinstate or approve license applications for U.S.-built satellites intended for launch on Chinese-built launch vehicles unless the President makes a report to Congress that: (1) China has achieved certain political and human rights reforms, or (2) the reinstatement or approval of an export licence is in the national interest of the United States. In December 1989, President Bush announced that export of the satellites is in the national interest, and the licenses were reinstated. The Asiasat-1 launch is scheduled for Apr. 7, 1990.

Soviet Union. The Soviet Union is offering launch services using any of its launch vehicles. The three that have drawn the most interest are the Proton, the Soyuz, and the new Zenit. The Soviets have used the Proton vehicle for over 20 years, and it reportedly can carry in the range of 2,000 to 4,000 kg to geostationary orbit. The Soyuz booster, in use since the late 1950s, is the most often used launch vehicle in the Soviet space program and can lift 7,500 kg into low Earth orbit (among its many uses is launching crews to space stations). The Zenit booster, first launched in 1985, can lift 15,000 kg to low Earth orbit, and the Soviets have announced that eventually it will replace the Soyuz booster.

A West German company has contracted with the Soviets for several launches of the Photon spacecraft on the Soyuz vehicle; Photon is a Soviet spacecraft designed for materials processing experiments. On July 29, 1989, Space Commerce Corp. of the United States, and Technopribor of the Soviet Union, signed an agreement to jointly develop and market a new commercial mobile launch vehicle derived from Soviet SS-20 medium-range nuclear missile technology. The booster will be named Start and will be capable of carrying a 650 kg payload at an estimated cost of $4-5 million per launch. Space Commerce (which markets launch services for the Soviet agency Glavcosmos) also announced in November 1989 that it had its first U.S.

customer for Soviet launch services. The contract, between the U.S. Energetics Satellite Corp. and Glavcosmos, reportedly is worth up to $54 million and involves two launches, with an option of six more, beginning in late 1990. The satellites, called SAT/TRAC, are for navigation and would be launched as secondary payloads using the Proton launch vehicle. The price for each launch reportedly is $6.5 million, and the company asserts that there should be no technology transfer concerns since the satellites use well-known technology.

The Reagan Administration prohibited the export of any satellite containing U.S. components to the Soviet Union for launch. The Bush Administration has not changed this policy. The issue became more complicated in 1989 when a private company, Cape York Space Agency (CYSA), proposed that they would buy Zenit launch vehicles from the Soviet Union for launch from Cape York, Australia. Thus, the satellites would not be exported to the Soviet Union, but to Australia, and launched on Australian-owned, rather than Soviet-*owned* launch vehicles. In addition, CYSA proposed that the satellites be processed by a U.S. company at the Australian launch site. The company argued, therefore, that there would be no technology transfer concerns. Because the launch vehicles would be *manufactured* by the Soviets, though, some Members of Congress have expressed concern that the services would be offered at unacceptably low prices and adversely affect the U.S. launch services industry (see **Issues**).

According to press reports, the Executive Branch does not plan to approve an application by a U.S. company to work with CYSA as launch site manager, chiefly because of the economic competition argument. CYSA stresses that it is still in the process of determining the feasibility of building a launch site at Cape York, not actually building the site today.

Language in the FY1990 Commerce, Justice, State and Judiciary Appropriations act (P.L. 101-162) prohibits the expenditure of any funds in the act for approval of license applications for launches of U.S.-built satellites on Soviet-built launch vehicles unless the President makes a report to the Congress that such an approval would be in the national interest of the United States. Although the FY1990 NASA authorization bill did not clear Congress yet (see **Legislation**), the House and Senate versions of the bill do contain language on this topic. The House language would prohibit launches of U.S.-built satellites on Soviet-built vehicles unless an agreement was reached ensuring that the Soviets engage in "fair pricing." The Senate language expresses the sense of Congress that the existing prohibition on launching U.S. satellites on Soviet boosters in the Soviet Union should also apply to Soviet boosters launched from other nations.

Japan. Japan also has a launch capability, although it currently launches only its own satellites. Through a bilateral agreement, Japan's N-I, N-II, and H-I launch vehicles, which are derived from American technology, can launch satellites for other countries only with the consent of the United States. However, Japan is developing a new launch vehicle, the H-II, which will not use U.S. technology and thus will not be constrained by this agreement. The H-II, scheduled for launch in 1993, will be capable of launching 2,000 kg into geostationary orbit. The Japanese already have an indigenously produced launch vehicle, the Mu, but they apparently consider it too small to offer on the commercial market.

An additional constraint on Japanese launch capability is a government agreement with Japanese fishermen not to launch more than twice a year from each of its two launch sites (the fishermen must vacate the area near the site during a launch). This agreement might have to be changed before Japan could be a major supplier of launch services. Japan is also considering a new launch site, possibly in the Pacific.

Launch Requirements

Military Space

The Air Force stated in March 1988 that as a result of the shuttle accident and subsequent grounding of the shuttle, DOD would have to spend more than $10 billion to alleviate the payload backlog, and it would take 6 years to replace existing military satellites in orbit and bring the system up-to-date.

An official breakdown of DOD payloads waiting for launch in the near term has not been made publicly available, but probably includes: DSCS-III communications satellites, GPS navigation satellites, Milstar communications satellites, Space Test Program (STP) payloads, photoreconnaissance and other intelligence collection systems, and SDI experiments.

For the future, a continuing question is whether the United States will deploy a Strategic Defense System (SDS) using space-based weapons. Such a deployment could require many heavy-lift launch vehicle flights, and, according to DOD, would mean development of a vehicle like the ALS. If an SDS is not going to be deployed, then the need for ALS is less clear.

U.S. Government Civilian Space

Shortly after the *Challenger* accident, the National Research Council's Space Science Board recommended making ELVs the primary launch vehicle for space science spacecraft. A major problem had developed for the space science community following the *Challenger* tragedy because most space science spacecraft were built specifically for launch by the shuttle. Three major space science missions were scheduled for launch in 1986: the U.S. *Galileo* mission to Jupiter; the European *Ulysses* mission to study the Sun; and the Hubble Space Telescope, a U.S. astronomical observatory. All were rescheduled for launch in 1989 or 1990, but scientists are concerned about the length of time (often 10 years or longer) between the start of each of these programs and when data actually are available for analysis. The *Galileo* mission suffered the most severe setback because the *Challenger* disaster led NASA to conclude that the type of upper stage it had been planning to use (the Centaur) was not safe for launch on the shuttle. Thus, the spacecraft used a less capable upper stage and it will take 6 years, instead of 2, to reach Jupiter. Launched in October 1989, it will arrive there in 1995, almost 20 years after the program started. NASA is now looking at ELVs as an alternative to the shuttle. Of special interest to some members of the space science community is the potential of the Pegasus booster and other "Lightsat" concepts. An ability to launch small spacecraft

quickly could ameliorate the problem with *Galileo*-type missions which take so long to reach fruition.

A larger question is what future U.S. Government civilian space activities will require. Proposals to return humans to the Moon or send crews to Mars would probably require much more capable launch vehicles, such as the ALS.

Commercial Users

Many U.S. and foreign communications satellite users were planning to launch their spacecraft on the space shuttle. Following the *Challenger* tragedy, however, President Reagan announced that the shuttle could be used only for U.S. Government satellites except for "shuttle-unique" spacecraft (those capable of being launched only by the shuttle) or launches that involve overriding foreign policy concerns. These commercial communications satellite customers have turned to U.S. or foreign ELVs for launches (one, Contel, has filed suit against NASA for breach of contract).

Many commercial users still allowed to use the shuttle have suffered delays because of the hiatus in shuttle flights, and will continue to experience delays because of the reduced shuttle flight rate. Many are small experimenters interested in "Get Away Specials" for small self-contained experiments, while others are companies who want to perform microgravity materials processing experiments. NASA has many "joint endeavor agreements" whereby companies (including McDonnell Douglas and 3M) are given free space on the shuttle to conduct experiments in exchange for sharing the resulting data with NASA. How often such experiments will be able to fly on the shuttle in the future is an open question.

Issues

Launch Vehicle Choices and Space Program Goals

Perhaps the greatest issue facing the Nation with regard to launch vehicles is determining the future course of the U.S. space program so that launch vehicles can be procured and/or developed to meet those needs. If the United States is going to have a vigorous space program involving Earth orbital and deep space missions, then a wide variety of launch vehicles will be needed, including existing and new systems. If a Strategic Defense System is going to be deployed, or humans are to be sent to Mars, a heavy-lift launch vehicle like the Advanced Launch System would probably be needed. If, conversely, the United States chooses to have a relatively steady state space program, focussing on only gradual improvements in the types of military and civilian space systems currently in use plus construction of the space station, existing launch vehicles with some evolutionary improvements could suffice. Until the direction of the space program is determined, choices among the various options -- developing Shuttle-C and/or ALS for cargo, Shuttle II and/or a NASP-derivative for carrying people -- will be extremely difficult to make.

Launches on Foreign Vehicles

Congress and the Administration have taken many steps to facilitate the success of U.S. commercial launch services companies. Currently, the launch services companies are primarily concerned about potential unfair competition from China and the Soviet Union who could offer launches for significantly lower prices. Even when the Reagan Administration approved the export licenses for U.S. satellites to China, it pointed out that such export decisions were being made on a case-by-case basis; there is no guarantee that any other licenses would be granted. To win approval for export of the Asiasat and Aussat satellites in 1988, China agreed to adhere to fair marketing practices, but European officials now are protesting a Chinese contract with the Arabsat Consortium for launch of a satellite at what they consider less than fair market price. American officials have stated that the issue will be discussed at meetings with the Chinese already scheduled for June.

The Reagan Administration stated categorically that it would not permit any satellite containing U.S. components to be exported to the Soviet Union, even though the Soviet Union stated it would waive all customs inspections and allow the satellite owner to remain with the satellite throughout its stay in the Soviet Union to ensure that there is no transfer of technology.

While launch service companies might welcome a decision not to allow Chinese or Soviet launches, satellite manufacturers could be adversely affected if their customers choose to have satellites built by foreign firms to avoid U.S. restrictions. How this situation will develop is unclear, however, since European, Canadian, and Japanese companies are the only other communications satellite builders in the free world, and those countries, together with the United States, belong to COCOM, which also must approve export of Western satellites to China and the Soviet Union. COCOM approved the three satellites for Chinese launch, but can be expected to carefully monitor, and regulate if necessary, launches of Western satellites on Soviet and Chinese launch vehicles.

Other U.S. companies also could be adversely affected by policy decisions designed to help the U.S. launch vehicle industry. For example, press reports indicate that an application by U.S. Space Boosters Inc. (USBI, a division of United Technologies) to provide technical assistance to the Cape York Space Agency (CYSA) will not be approved. USBI is considering serving as the manager of the Cape York launch site, but requires government approval of a Technical Assistance Agreement (TAA) in order to work with CYSA. If the TAA is not approved, CYSA has indicated that it will approach European companies about serving as launch site managers (British Aerospace and Germany's MBB have been mentioned in the press as likely candidates).

Facilitating the U.S. Commercial Launch Services Industry

In addition to the actions it has already taken to facilitate the commercial launch services industry, Congress continues to express interest in assisting the industry, both by attempting to protect U.S. companies from unfair pricing by foreign competitors (particularly China and the Soviet Union), and by increasing the market for commercial companies by forcing government agencies to procure commercial launch services instead of buying the ELVs themselves). In 1989, Representative

Packard introduced H.R. 2674, the Space Transportation Services Purchase Act, which, among other things, would require DOD to purchase launch services as well (with certain exceptions). Also, language in the House-passed version of the FY1990 NASA authorization act would clarify government policy to use the space shuttle only for activities that require interaction with a crew, rather than launching spacecraft that could be launched on ELVs instead. This could further expand the market for launch services by moving satellites off of the shuttle and onto ELVs. As noted elsewhere, the bill did not clear Congress yet.

LEGISLATION

H.R. 4196 (Roe)/S. 2287 (Gore)

National Aeronautics and Space Administration Authorization Act of 1991. Authorizes appropriations for NASA for FY1991. H.R. 4196 introduced Mar. 6; referred to Committee on Science, Space and Technology. S. 2287 introduced Mar. 9; referred to Committee on Commerce, Science and Transportation.

H.R. 2256 (Solomon)

Prohibits the export of satellites intended for launch from launch vehicles owned by Soviet Union. Introduced May 4, 1989; referred to Committee on Foreign Affairs.

H.R. 2624 (Solomon)

Prohibits the export of satellites intended for launch from launch vehicles owned by China. Introduced June 26; referred to Committee on Foreign Affairs.

H.R. 2674 (Packard)

Space Transportation Services Purchase Act. Sets forth requirements for the Federal Government in procuring commercial space transportation. Introduced June 15, 1989; referred to Committee on Science, Space, and Technology.

H.R. 3729 (Roe)/ S. 916 (Gore)

National Aeronautics and Space Administration Authorization Actof FY1990. Authorizes appropriations for NASA for FY1990. Original bill H.R. 1759 introduced Apr. 10, 1989; reported from Committee on Science, Space, and Technology (H.R. 101-226) Aug. 31. Passed House, amended, Sept. 21; referred to Senate Committee on Commerce, Science, and Transportation Sept. 25. S. 916 introduced May 3, 1989; reported with amendment from Committee on Commerce, Science, and Technology (S.Rept. 101-157) Oct. 3. Passed Senate, amended, Nov. 9. New bill H.R. 3729 introduced Nov. 19; passed House Nov. 20. Passed Senate, amended, Nov. 22, 1989. Conferees named by House, Feb. 28, 1990.

S. 2171 (Nunn)

Authorizes appropriations for the Department of Defense for FY1991. Introduced Feb. 26; referred to Committee on Armed Services.

CONGRESSIONAL HEARINGS, REPORTS, AND DOCUMENTS

U.S. Congress. House. Committee on Science, Space, and Technology. H.R. 3765, the Commercial Space Launch Act Amendments. Hearings, 100th Congress, 2d session. Feb. 16, 17, 1988. Washington, U.S. Govt. Print. Off., 1988.

U.S. Congress. Senate. Committee on Armed Services. Air Force space launch policy and plans. Hearing, 100th Congress, 1st session. Oct. 6, 1987. Washington, U.S. Govt. Print. Off., 1987. (S.Hrg. 100-505)

U.S. Senate. Committee on Commerce, Science, and Transportation. Commercial expendable launch vehicle liability. Hearing, 100th Congress, 2d session. May 17, 1988. Washington, U.S. Govt. Print. Off., 1988. (S.Hrg. 100-750)

FOR ADDITIONAL READING

U.S. Congress. Office of Technology Assessment. Big dumb boosters: a low-cost space transportation option? OTA background paper. Washington, February 1989. 25 p.

----- Launch options for the future: buyer's guide. Washington, 1988. 99 p.

----- Reducing launch operations costs. OTA technical memorandum. Washington, September 1988. 94 p.

----- Round trip to orbit: human spaceflight alternatives. Special report. Washington, August 1989. 116 p.

U.S. Dept. of Defense/ National Aeronautics and Space Administration. National space launch program; report to Congress. Washington, 1989.

U.S. Library of Congress. Commercial space activities in Europe, by Patricia E. Humphlett. Washington, 1988. 10 p.
CRS Report 88-531 SPR

----- National Aero-Space Plane, by John D. Moteff and David P. Radzanowski. [Washington] 1989. (Updated regularly).
CRS Issue Brief 89128

----- Soviet space commercialization activities, by Marcia S. Smith. Washington, 1988. 7 p.
CRS Report 88-473 SPR

----- Space commercialization in China and Japan, by Karl A. Rohrer and Marcia S. Smith. Washington, 1989. 14 p.
CRS Report 89-367 SPR

----- U.S. space commercialization activities, by Patricia E. Humphlett. Washington, 1988. 10 p.
CRS Report 88-518 SPR